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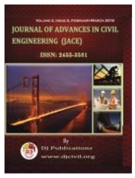

REVIEW ARTICLE

Analysis of Benefits, Advantages and Challenges of Building Information Modelling in Construction Industry

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ABSTRACT

Building Information Modelling (BIM) has become a well-known established extensive collaborative process and an important area of development in the Architecture, Engineering and Construction (AEC) industry and has transcended all disciplines. The use of BIM in construction projects can possibly increase the information quality needed for making critical design decisions to access a building's environmental impact. Analysis, design and infrastructure of buildings are formulated with the help of samples generated from BIM. In the last decade, BIM has witnessed an increasing development. This was a result of their rapid capabilities applicable to construction projects. BIM can generate a common language for all divisions of parties and systems in a project and make them a combined team. The BIM method is strongly matched with delivery systems for integrated projects. Harnessing the unrealized possibility of the full life cycle use of the model by integrating it with the amenities and property management phases of buildings and infrastructure is one of the advantages of BIM which makes it suitable to the industry. This analysis is intended to show the correspondence of BIM and project manager's roles on construction projects. It insists on the significance of proper knowledge and experience of project managers to get succeeded in BIM. Initially, this review presents an in-depth analysis of present literature frameworks and surrounding methodologies to assess and examine the BIM advantages and static design. Then 3D, 4D BIM and BIM based scheduling techniques are examined. The use of the term 4D to refer to the fourth dimension time is also discussed. i.e. 4D is 3D + schedule (time). The role of 4D BIM is to add a novel dimension to 3D CAD or solid modelling. The paper also reviews the issues regarding the BIM implementation, static design and intrinsic problems related with an attempt to assess the advantages in a purely quantitative fashion. Through the application of BIM technology for the dynamic querying and statistical investigation of construction schedules, engineering, resources and costs are the three implementations considered to be proved as how BIM can ease the extensive grasp of a project's implementation and progress. Recognition, conflict solving, contradictions between construction resources and control costs, decreasing project over-spends and protecting the resource supply are also dealt with. A BIM overview with specifications on its core and cycle concepts, benefits of the project life with the help of surveys has been discussed. The paper also elaborates risks and obstacles in BIM implementation and future BIM trends.

Keywords: Construction projects, Solid modelling, BIM, 3D CAD, Scheduling.

1. INTRODUCTION

There are various problems in construction industries related to construction costs, low-carbon emissions, environment-friendly constructions, green buildings, social responsibility, natural ecologies and welfare. Building Information Modelling (BIM) is one of the ways for changing the approaches to project maintenance, design and construction. The BIM Handbook [1] defined BIM as a technology of computer-aided modelling for the purpose of managing construction project information concentrating on building information, models, production,

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communication and analysis. The committee for National Building Information Model Standard Project (NBIMS) defined BIM as "A BIM is a digital representation of physical and functional characteristics. It helps in shared knowledge resource for information about a facility forming a dependable source for decisions in the course of its lifespan from beginning onwards." This review paper defines sustainable design as the design processes and practices that contribute to sustainable patterns of living throughout the built environment based on the method of 'triple bottom-line'. An example of a shift from steady notions to regenerative influences is provided. BIM build environment accounts for the ecological, social and economic health of the place. To attain this, common understanding among several stakeholders is required. A move from an isolated and static building performance understanding in terms of design discourse to an extensive and dynamic discourse that encourages an understanding of the building lifecycle implications on occupant lives and business success will involve and preserve stakeholder dedication [2].

In this analysis, the applications of BIM which contain visualization, three dimensional coordination, prefabrication, construction planning and monitoring, estimation of cost and model for record are discussed in detail. The tools of BIM are analysed by means of a prototype 3D and 4D house model. Moreover, BIM is analysed as the main generator for 4D scheduling. Although tools used for BIM results in some shortcomings such as issues in interoperability, the application of BIM is very beneficial to the construction managers.

The purpose of this analysis is to address this issue by quantitatively comparing BIM treatments with non-BIM treatments in an actual BIM embedded project. For the accomplishment of this objective, a review of BIM based on a real plan containing measureable and profitable proof has been provided. As construction concerns a wide activities range with dissimilar natures, it is evenly important to establish methodological protocols and metrics to evaluate the performance and benefits derived from any specified aspects.

With current legislation stipulating the minimum necessities for sustainability, this is inevitably perceived by project teams as supplementary to the primary goals and budget. [3] refers to [4] and the suggestion for sustainability is given by a meaningful comment as 'novel concepts and tools that are integrative and synthetic, non-disciplinary and analytic and that vigorously generates synergy, not just summation'.

The purpose of this paper is to provide an overview of BIM concept, uses, advantages, risks and related challenges in AEC industry. This is followed by analysis of BIM benefits for project stakeholders namely proprietors, designers, constructors and facility managers. Then the risks and barriers of BIM to be implemented in the AEC industry are explained. Finally, the BIM features are analysed.

2. TECHNOLOGY OF BIM

As indicated in figure A1, a Building Information Model (BIM) consists of a 3D project model linking design, planning, construction and operation [5]. The BIM idea arises from the object-oriented parametric modelling technique [6]. The term "parametric" defines a procedure by which the assembly is automatically adjusted to preserve a previously found relationship [7, 8]. The main difference between BIM conventional 3D and CAD technology is that the latter labels a building by independent 3D views such as elevations, plans and sections while the former does not label in such a manner.

According to the BIM regulation of planning [9], the plan for BIM construction of Wuhan New City International Expo Centre is created. Based on the construction plan, the model of BIM is figured out as shown in figure A2. Based on the purpose of operation, the characteristics are embedded into the model of BIM.

3. BIM PROCESS

BIM can be observed as a virtual process where all features are encompassed and disciplined. Systems of a facility within a distinct, virtual model permit all team members to co-operate better than the traditional processes. Today, BIM is perceived only as advertising for software companies. BIM can be regarded both as software and an integrated method which is shown in figure A3 [10]. On the other hand, the applications of BIM are practised in industries such as construction, information technology, and software and hardware fields. While considering the Building Information Modeling (BIM), 3D model is mostly considered to be fake. It must be noted that BIM is fundamentally a data package. It involves all information about construction, design, buildings management and renovations. 3D model is one of the several possible ways of this information description.

Recently the concept of Integrated Project Delivery (IPD) emerged as a natural companion to BIM. In the US, [11] the IPD has become a favoured project delivery system for all main projects involving BIM. Figure A4 illustrates the contrast between the "traditional" and "BIM" process.

4. STUDY OF BIM TOOLS

The main part of this review is the study of the benefits and uses of building information models in construction projects.

4.1. 3D modelling of a house

[12] It was downloaded from the website of Autodesk's student community to develop a model for 3D house. At first, a novel Revit file is created and saved. Then, the walls for the perimeter are created. Once the perimeter walls are finished, the interior walls are formed. After that, [13] the foundation walls, flooring, windows, doors, stairs, deck, roof are created. Moreover, the rooms are tagged. For this no mechanical, electrical, plumbing elements are required. The 3D modelling and 2D drafting differences are reviewed. Also, the object granularity including the elements decomposition is explored [14].

4.2. 4D modelling of a house

4D modeling requires a 3D model development and schedule. The 3D model is created in [12]. The Microsoft project uses a method of critical path to create the schedule. Synchro's 4D BIM tool was downloaded through its website. In [15] it is used as the existing model integrator in IFC format and in the Microsoft project in xml format. Once the model and the schedule are introduced into the tool of Synchro's integration [16], the resources of IFC which are the building elements list are connected. Once the connecting of 4D is finished, focused time and animation can be used to generate videos of the 4D model. Finally, the video file can be exported. From the analysis [17] tools do not offer the 072-9 information essential to create a 4D visualization of the project progress. For this problem, the solution is 4D BIM, which is created by mixing the 3D BIM with project schedule. It permits the 3D simulation of a building and its mechanisms. It can assist in problems prediction and calculating the quantities of material.

5. FEATURES OF BIM TECHNOLOGY

There are some specific aspects of BIM that helps in their effective implementation in project management. These attributes, developed progressively can be explained as follows [18]:

5.1. Constructability

BIM helps the team members of a project in reviewing and handling constructability and RFIs issues. Furthermore, visual information can be provided from an advantage point focussing on problems occurred. All these information associated with mark-up helps in finding solutions and mitigating risks.

5.2. Investigation

Another aspect of BIM helps project managers, engineers and designers to do more examinations and provide better decisions [19]. By connecting BIM tools, it would be enough to investigate the construction project energy consumption and to find improved solutions such as varying orientation, mass and space of materials etc. Furthermore, analysis of light, mechanics and acoustics can also be performed by BIM [20].

5.3. Quantity take-off

Quantity take-offs are very useful for project managers and teams to study their choice and have dependable insight into several alternatives throughout the lifecycle of the project. Since there is availability of an opportunity between the database and BIM model a correct estimation can be received much faster. Additionally, these items for take-off can be used easily in procurement process [21].

6. MANAGEMENT OF CONSTRUCTION PROJECT

Construction is the significant part of all projects [22]. These projects can be either retail projects or small residential projects of mega multifunction. The construction project management requires an understanding of modern management knowledge of different construction procedures. With the variations in organizational procedures, technology and new methods, the process of construction management differs [23]. Management of construction project refers to a sequence of activities in order to determine the conduction work flow in the life cycle. Similar to Project Management Body of Knowledge (PMBOK), the manager handles planning of project management, cost, quality, time, contract administration, risk and safety management. The manager is also the communication authority between investors, designers, owners, engineers, professional crew and administrative staffs [24]. Normally, management of construction project shares the common and overall properties of general projects. Hence, the rules and approaches necessary for the management of general projects can be applied to this type of projects.

Aggregating the related data cost later, the database which involves engineering data dispersed among several industries is shown in figure A5. Based on the database, figure A6 illustrates how people from different departments and sectors are permitted to involve in the management of materials via the database for BIM.

7. PROJECT CONSTRUCTORS

General contractors adopt BIM compared to all other stakeholders [25]. The BIM can be used by the contractors and subcontractors for the following uses [26]. (1) Cost estimation and quantity take-off, (2) Early design error identification, (3) Analysis for construction planning, (4) Onsite verification and construction tracking, (5) Offsite modularization and prefabrication, (6) Site conservation planning, (7) Value engineering and (8) Better communication with designers, owners, subcontractors and workers. [27] Hence the following advantages are achieved by the constructors. (1) Improved profitability, (2) Good customer service, (3) Schedule and cost compression, (4) Better production quality and (5) Good decision making. The project architect develops the architectural model. The 2D structural and MEP system drawings are acquired by prime contractors from project engineers and converted them into 3D BIM models [28]. All "single" BIM models are integrated through detections of clash in the phase of preconstruction. The prime contractor is able to save $259,000 roughly as demonstrated in figure A7.

8. CHALLENGES

In the current review, [29] shows that if there is disbelief among the project team members about the importance and benefits of BIM on construction projects, satisfactory results will not be obtained. [30] shows that BIM's top investment areas include hardware, software and interior collaborative development BIM workflow. [31] states that the BIM challenges can be categorized as 1) technical challenges, 2)skills and training challenges 3)legal procedural challenges and 4) economy which can obstruct the firms from upgradation of their available systems to a system which is BIM oriented.

Certain quasi-tangible advantages in the construction industry are information availability, productivity and improved decision making capability. The intangible advantages include competitive benefits, market access and better risk management [32]. Challenges of the imperceptible considerations include the calculation of monetary terms. These studies are viable to estimation and instinct. Moreover, these advantages are mined from business procedures and purposes. The independent expression to support system objectives are not provided [33]. Lack of formal methodologies or procedures to establish a BIM business case results in uneven speculation and improper estimation. Approaches have been put forward to assess the information systems. But most of them are prescriptive and reactive in nature, depending on perception values.

9. BENEFITS AND ADVANTAGES OF BIM

Various construction project management sources recognize certain BIM advantages which are indicated as follows [34]

- Better performance and quality of the project
- Improved productivity
- Reduction of wastages
- Faster delivery
- New opportunities for revenue and business
- Low construction cost

If BIM is considered as a centralized source, it can enable persons involved in the construction industry to get the same data version. Consequently the communication risk of project managers can be mitigated [35, 36]. Analysis of feasibility and design concepts, results in improved quality and performance of the building. It is the key to achieve the BIM benefits in the pre-construction phase. Further automatic low-level alterations and accurate design of visualizations are required during transitions. Generation of 2D drawings, multiple design parties collaboration, extraction of cost estimation, sustainability improvement and energy efficiency are the advantages in the design phase of the construction project. BIM design, detect and synchronize errors, construct and design omissions and planning, use design models as a base for fabricated components and also enable lean construction techniques. Furthermore, BIM would implement improved operation facilities and post construction phase management.

There are different BIM tools that have been established to tackle sustainability concerns in the construction procedures from design inception to facility management [37-41]. These technologies can assist in attaining the outcomes specified by sustainable assessment methods. The mechanistic approach required to achieve the credits fail to arrest and may result in denial of humanistic and developmental benefits BIM may bring in terms of dialogic stakeholder engagement, common understanding and values internalisation in sustainability. BIM is very often depicted in the process of design and construction although the whole lifecycle should be in the preview of BIM implementation. The application of building information modelling enables reducing the challenges of interoperability and integration for facility management [42, 43].

10. CONCLUSION

The studies show both the BIM advantages and disadvantages. The project recommends BIM application to construction managers with a note on the challenges of using BIM tools. The construction components and scheduling progress are run by BIM based 4D scheduling which results in good construction planning. Additionally, building information modelling tools examine the enhanced usage of 3D, 4D and model scheduling. This specifies the definite forward movement of the construction industry along with BIM and BIM tools. Therefore, BIM can be regarded as a decision-making tool despite it being technical equipment. This viewpoint is the outcome of an extensive BIM description. In construction projects similarities between the role of a project manager and BIM require clear understanding of the BIM concepts. Aimed at this purpose, BIM should be included in the construction curriculum. A brief explanation of project management should be given for scholars who intend to pursue positions in project management as their profession.

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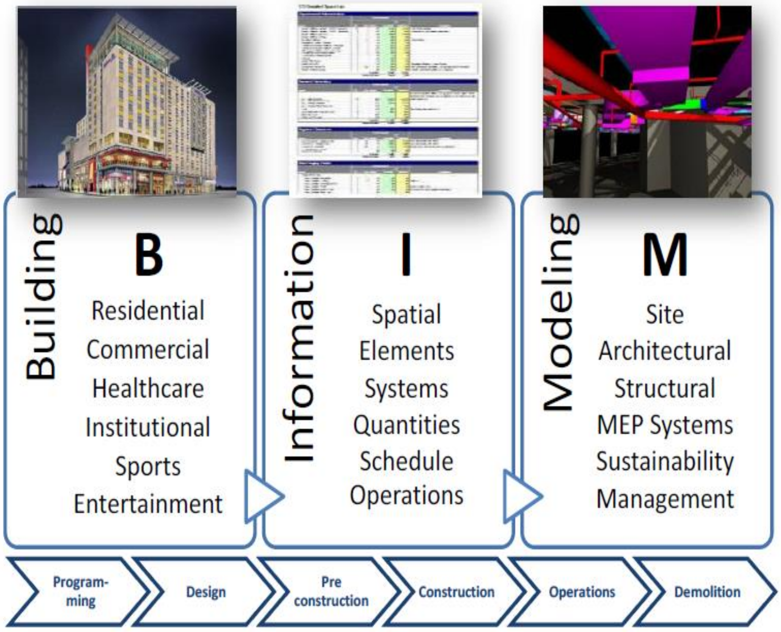
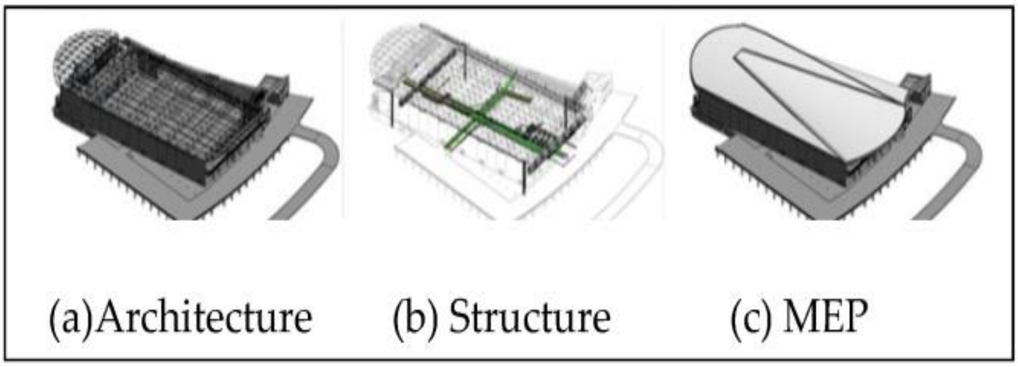
APPENDIX A



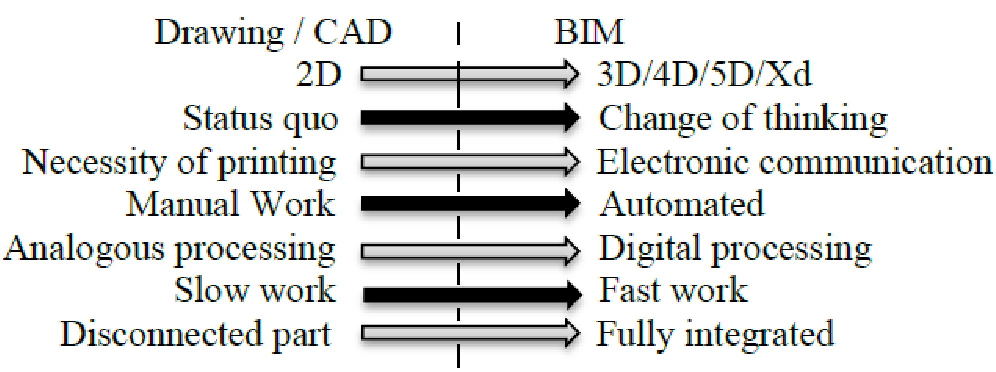
Adapted from [5]

Figure A1.A Schematic representation of BIM model



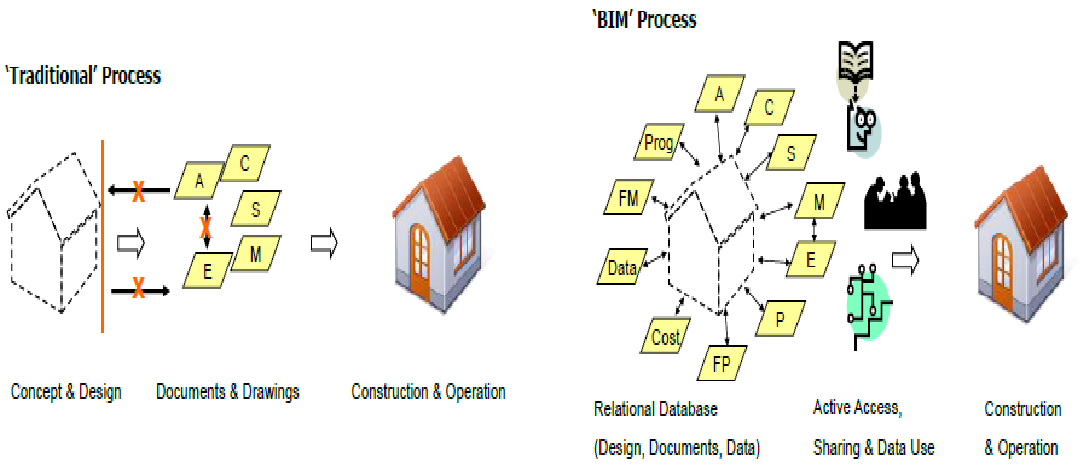
Adapted from [9]

Figure A2.BIM model of Wuhan new city international expo centre



Adapted from [10]

Figure A3.Process of transitions CAD vs. BIM

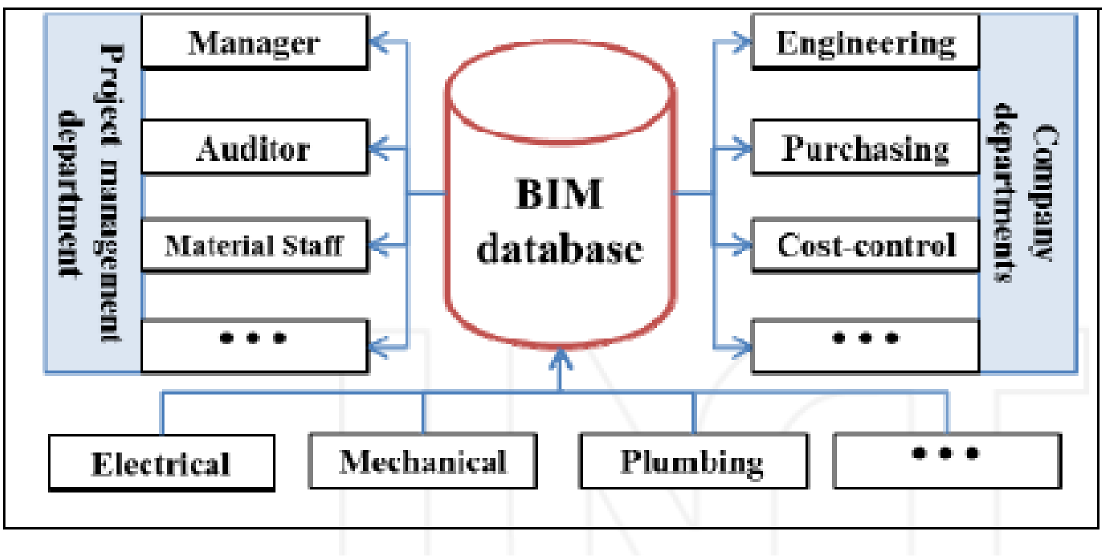


Adapted from [11]

Figure A4.Difference between "traditional" process and "BIM" process [11]

Adapted from [28]

Figure A5.A BIM model database establishing the process of materials installation



Adapted from [28]

Figure A6.Configuration diagram of the BIM database for management of materials

Item	# Of Collisions	Estimated Cost Avoided	Estimated Crew Hours		Coordination Date
Construction (MEP/ Structure Collisions)					
Basement	9	$2,041	5.5	hrs	*December 12, 2007*
Level 1	107	$93,050	188	hrs	*April 14, 2008*
Level 2	43	$41,913	87	hrs	*February 14, 2008*
Level 3	78	$61,070	132	hrs	*May 12, 2008*
Level 4	65	$33,525	77	hrs	*February 29, 2008*
Level 5	87	$78,543	164	hrs	*April 22, 2008*
Penthouse	25	$25,684	52	hrs	*May 12, 2008*
Subtotal Construction Labor	414	$335,826	705.5	hrs	
15% Material Factor		$50,374			
Subtotal Cost Avoidance		$386,200			
Deduct 33% assumed resolved via conventional methods		($127,447)			
Approximate Cost Avoidance		**$258,753**			

* Direct Collision Detection Savings Only. Indirect Savings (i.e. General Conditions, Escalation, Design on Construction Administrative Time Savings Not Included.)

Adapted from [11]

Figure A7.BIM applications in the stage of project preconstruction